The Effect of Sorghum Stalk Silage Supplementation on Milk Production and Composition of Indigenous Milking Cows in the Peak Dry Season at ShoaRobit, Ethiopia

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Abstract

In the semi-arid areas of Ethiopia, utilization of sorghum stalk as feed has shown significant growth annually due to the expansion of sorghum production. Sorghum stalk is the dominant crop residue conserved in the study area and farmers mostly rely on it to feed their draught oxen and milking cows during the dry season. Sorghum stalk is conserved in loose form in open air till it lasts without shade. Such practice leads to the loss of nutritive quality due to weathering and fermentation exposures. The use of concentrates and improved forages is nonexistence due to high cost and unavailability, leaving the poorly conserved crop residues as the only source of feed to sustain productivity. This study aimed at evaluating the total yield and composition of milk produced by lactating cows supplemented with sorghum silage in the dry season. Twenty-two indigenous milking cows of volunteer farmers were allocated into two treatments (silage supplemented and un-supplemented/farmers practice). Milk yield was higher ($P < 0.05$) for cows fed with silage than the un-supplemented group. Cows that are not supplemented with silage had poor body condition, as opposed to lactating cows fed silage. Cows in the supplemented group produced on average 2.26 liters of milk per day, which was significantly higher ($P < 0.05$) than the un-supplemented group (1.16 liters per day). The silage contained better protein content (6.59%) as compared to the dry stalk (4.38). Milk fat, protein, solid-not-fat and density were not affected by the treatments ($P > 0.05$). The result indicates that conservation of sorghum stalk immediately after grain harvest in the form of silage improves milk yield.

Key Words: - Milk, milk composition, sorghum stalk, silage, indigenous milking cows

Introduction

The major feed resources for livestock at Chare village, near Shoa Robit town include natural pasture and crop residues followed by sugar cane tops and crop aftermath (unpublished data). In the dry season, the reduction of grazing pasture in biomass leaves farmers with no alternative except the wide use of crop residues. However, crop residues have low nutritive value (Seyoum *et al*., 2007) and low digestibility (Leng, 1999). Open air storage of crop residues in stacks is common and widespread in parts of Ethiopia especially where mixed farming is practiced. In the semi-arid areas of Ethiopia, sorghum stalks are the dominant crop residue conserved as a dry season feed (Aschalew *et al*. 2014 unpublished; Tegene *et al*., 2013). Sorghum is native to Ethiopia (Ecoport, 2011), and has become the third most important cereal grain in terms of area coverage and second in terms of production (CSA, 2013). Expansion of arable land has consequently increased the use of crop residues as farm animal feed. Alemu *et al*., (1991) estimated the crop residue production of the country as 10.71 million tons per annum of which 70% of the residues is used as animal feed (Zinash and Seyoum, 1991). Significant quantity of sorghum stalk is produced every year in Kewet district, and almost all is conserved mainly as animal feed. After grain harvesting, the sorghum stalks stacked around homesteads are exposed to natural weather condition resulting in deterioration of quality. The nutritive value of stalks is influenced by weather (Kediija, 2008) and length of stacking period. The nutritive value of sorghum stalks can be preserved through silage making if properly ensiled, immediately after grain harvest (unpublished data). Ensiling ensures farmers to have quality feed to bridge the dry season feed shortage. Utilization of concentrates and improved forages in the mixed farming system of Shoa Robit do not show a lot of promise given the increasingly high cost of concentrates and land shortage for forage production .Use of alternative technologies such as silage making will have a vital role to play in planning dry season feeding strategies.

Because of the traits they acquired through natural selection over generations, indigenous livestock populations have been observed to have the capacity to use poor quality feed (Azage *et al*., 2010). In Ethiopia 98% of milk comes from the traditional system (Hizkias, 2000) and dairying is less developed and at very low level as compared to that of neighboring countries (Zegeye, 2003). Demand for dairy products is increasing in towns and cities due to large population size and high income. However, peri-urban and urban dairy farms produce only 2% of the total milk production of the country (Hizkias, 2000), and this low contribution, amongst many to the feed inadequacy both in quantity and quality (Azage *et al.,* 2006). Dairying is a strategic enterprise as a source of nutrition to households, and as income and employment generator. In order to maximize milk production at subsistence farmers level, the focus need to be given to improvement of available feeds. No research has been reported regarding milk yield and its composition from indigenous cows that fed on sorghum stalk silage, thus, this study was conducted to evaluate the performance of indigenous milking cows supplemented with sorghum stalk silage at the peak of the dry season, and how this effects milk yield and milk composition.

Materials and Methods

Site description

The experiment was conducted at Chare village, Kewet district, with longitude of 39.90^{o}E and latitude of 10.00^{o}N, in Northern Shoa. The site is characterized by low and variable rainfall (760.20mm/year on average, mostly raining from July to September) and high evapo-transpiration (1579mm/year) that leads to agricultural risk. The temperature, which is relatively hot, ranges from 10.9 to 29.72^{o}C, the maximum being 34.39 in June and the minimum 11.91^{o}C in January. Sorghum is the major crops cultivated in Kewet district (Bureau of Agriculture, 2013, unpublished data).

Sorghum planting, harvesting, and ensiling

Teshale, a sorghum variety released for its grain yield, was planted on a well-prepared seedbed at the onset of the main rainy season at a rate of 15 kg/ha, and was fertilized with urea and DAP at the rate of 50 and 100 kg per ha, respectively. Stalks were collected just after grain harvest and were chopped using motorized chopper to a size of 2 – 4 cm and mixed with additives (molasses and urea). To keep out any possible air entering into the silage, all pits were covered with a plastic layer before the silo was enclosed with soil and stone. Urea and molasses were used as additives since commercial inoculants and enzymes are costly and unavailable in the village.

Local tools were used to dig, fill and carry the chopped sorghum stalks in to the pit. The pits that were used in this study were dug 1m long, 1m wide and 1m deep giving a total volume of one cubic meter. Neither the floor nor the walls of the pits were cemented. Each pit was dug close to the barn to minimize labor cost and wastage at time of feeding. The silos were opened after maturation and it was found out that fermentation has taken place properly. Tests made on odor, color and smell confirmed that the silage was of good quality. Representative silage samples were collected from each silo and bulked for analysis. Samples from stacked sorghum stalks were collected from farmers' fields at 15 days interval to see if there is any change in nutrient composition during the long storage period.

Feeding milking cows

The feeding experiment was conducted on-farm using volunteer farmers having milking cows in the dry periods. Initially thirty farmers were selected from the village; out of these 18 farmers were selected to prepare 1m^3 pits and fill with chopped sorghum stalks for ensiling. Of these 11farmers were selected in the actual feeding experiment. From the 12 farmers who did not prepare silage 11 of them were used as control farmers. The twenty-two cows were grouped into two based on parity, stage of lactation and milk yield (supplemented and un-supplemented). Body weights were recorded using heart-girth measurements before and at the end of the experimental period. During the acclimatization period, silage was provided to have 10 to 20% refusal. Cows were hand-milked twice daily, early in the morning, and late in the evening, and summed each day for daily milk record. The silage was fed individually in the morning and evenings after milking until the end of the experiment. The trial consisted of a 2-week adaptation period followed by a 4- week experimental period. Milk samples of 100.00 ml were collected at the mid of the experimental period from morning and evening milking rounds for analysis.

Sample and Statistical analysis

Feed samples were dried in a forced draft oven at 60°C for 72 hours, and ground with a hammer mill to pass a 1.00 mm sieve and analyzed for dry matter (DM), and crude protein (CP) according to AOAC (1990) procedures. NDF, ADF and ADL were determined by the methods of Goreing and Van Soest (1970). Milk samples were analyzed to determine milk protein, fat, SNF and density. Fat and protein contents were estimated using (O'Connor, 1994 and 1995), while the solid-not fat content was determined using Richardson, (1985) methods. The Student t-test was used for the statistical analysis of milk yield and its compositions.

Results and Discussion

Chemical composition of sorghum stalk

In the dry season, sorghum stalk is used as supplement during milking period and at enclosure time. Poor stacking method that exposes the sorghum stalk to natural calamity throughout the season results in low nutritional value. Famers usually pile sorghum stalks in open air without any cover; and have a tradition of protecting the stalks from the reach of animals using stones, wood and/or thorny acacia branches. The nutrient content of the dried stack decreases as the stalks were kept longer in an open-air without shade (Table 1). Nutrient composition of the dried stalks is low in CP and high in fibers. The CP content decreased with the period of storage reaching 4.38 within 42 days. Open-air storage without shade aggravates the nutrient composition deterioration. The higher concentration of ash observed in the silage and sorghum stack is associated with the sandy soil of the locality where there is high chance of soil contact with the feed. CP concentration of silage was high and low values of NDF, ADF and ADL were obtained with that of sorghum stack (Table 1).

In sorghum growing parts of the country sorghum stalk is used as dry season feed and at Chare it comprises the main dry season feed without any additional treatment/s. Concentration of DM, CP, ash, ADF and NDF differ among sorghum stacks collected at different periods. CP content (5.66) was slightly higher for stack collected in the first sample than the latter ones (4.38) Table (1). The sorghum stalk had higher concentration of CP, NDF, ADF and ash than reported by Seyoum *et al*., (2007).The stalk is low in its nutritive value with a digestibility of lower than 50% (Blummel *et al*., 2003) due to its low protein and high fiber content (Seyoum *et al*., 2007). The nutritive value of the stalks is influenced by the method of conservation and length of time the stalks are kept in the field. Silage nutrient content was higher than the dried sorghum stalk of the same area (Table 1). The CP concentration of the silage 6.59% was found to be high than all dry feeds and was comparable with wilted browse acacia leaves and cactus clod (Seyoum *et al*., (2007) and than that of dry grasses (Aschalew *et al*., 2014). However, the CP obtained from the silage is still lower than the minimum threshold level of 7%; below which the intake of forage is markedly reduced (Milford and Minson, 1966). Strategic protein supplementation would therefore be necessary for efficient utilization of sorghum silage at Chare village, near Shoa Robit town.

Table 1. Chemical composition of silage and sorghum stalks sampled at different dates

Sampling period	DM	Ash	CP	NDF	ADF	ADL
Before ensiling	92	11.11	5.66	71.75	45.65	26.08
Stack, 09/02/14	92	11.11	4.49	79.56	57.57	31.52
Stack, 02/03/14	92	11.11	4.38	69.5	63.09	34.78
Farmers silage	92	12.22	6.59	66.81	51.27	29.81

DM, dry matter; CP, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; ADL, acid detergent lignin.

The stalk contained 65% moisture content at time of ensiling, which is in agreement with Undersander *et al*, (2003) of 65-70% moisture content for sorghum silage. The stalk CP content (5.66%) is comparable to that of Seyoum *et al*., (2007) of 5.1% harvested at dough stage and drastically dropped to 4.38% within 42days (Table 1). On the other hand, the silage CP increased to 6.59%, due to timely ensiling and urea and molasses inclusion. The sorghum silage composition presented in Table 1 is in agreement with the previous report of Aschalew *et al*. 2014) of Shoa Robit. For the resource poor farmers with limited access to commercial concentrate, the CP obtained from silage could mean a lot in maintaining or increasing milk production particularly during the dry season.

Milk yield

Silage intake at the initial stage was low and the refusal was high but stabilized to 6kg/cow/day before the end of the acclimatization period and continued with this amount till the end of the experimental period. Milk yield of supplemented and un-supplemented indigenous lactating cows is presented in Table 2. Differences in milk yield of the two groups were found to be statistically significant ($P < 0.05$) with cows supplemented with sorghum stalk silage producing higher daily milk yield than those on the control group. Similar results were also reported by Mesfin *et al*., (2009); Getu, (2008); Adebabay, *et al*., (2009) who indicated that treated crop residues produce more milk than the un-supplemented group.

The un-supplemented cows on the average produced 1.16 ± 0.48 liters milk $h^{-1}d^{-1}$, which is significantly, lower ($P < 0.05$) than the supplemented group 2.26 ± 0.48 liters. Succulence and higher CP content of the silage contributed to the significant yield difference between treatments (Table 2). The average daily milk yield performances of cows ranged from 0.5006 to 2.0877 liters with a mean of 1.16 liters for the un-supplemented group, while that of the supplemented group ranged from 1.3291 to 3.2660 with a mean of 2.26 liters per day.

The milk obtained in this study was found to be higher than the national average of 1.54liters/cow per day for the indigenous milking cows. This indicates that sorghum stalk silage can keep indigenous lactating animals on productivity without considerable drop during the dry season. Sorghum silage feeding increased lactation length and maintained the productivity of the supplemented cows during the dry season contrary to the un-supplemented cows. Under normal conditions, farmers milk their cows twice per day, early in the morning and late in the afternoon. However, farmers of Chare village milk only once in the morning in order to cope up with the dry season feed shortage. In general 64% of the supplemented cows gave two milking per day as opposed to 45% of the un-supplemented group.

Increasing number of milking days will evenly distribute the income obtained from the sale of milk in the season. This was one of the vested reasons given by the farmers for the uptake of the technology. Feeding of sorghum stalk silage in semi-arid areas could alleviate the critical feed shortage problem that usually occurs in the dry season.

The initial and final body weights of cows were not significantly different among treatments though body condition of the lactating cows seemed better for the supplemented group. As expected body weights have declined in both groups, though weight loss in supplemented group was slightly lower as compared to the un-supplemented group (Table 2). Body weight loss in the supplemented group may be due to longer period of milking than the un-supplemented group.

Table 2. Body weight and milk yield of indigenous milking cows with and without silage supplementation

Treatment	Body weight		Milk yield		
	Before	After	Daily milk	Morning	Evening
Supplemented	217±17.44	210±17.44	2.26±0.48 [a]	1.40±0.74 [a]	0.90±0.73
Un-supplemented	230±17.44	224±17.44	1.16±0.48 [b]	0.42±0.74 [b]	0.82±0.73
	NS	NS			NS

Means with different superscripts within the same column differ significantly (P <0.05). NS, not significant

Milk composition

The effect of silage supplementation and different milking time on milk composition is presented in Table 3. Silage supplementation did not significantly influence (P<0.05) the protein, fat, solid not total and density of the milk components (Table 3). However, silage supplemented lactating cows consistently produced more fat than the un-supplemented ones both during morning and evening milking hours. The lack of significant difference in milk composition (in both groups) is in agreement with the observation of Getu, (2008) and Adebabay *et al*., (2009). No significant difference was also noted between the morning and evening milking time in any of the milk components (milk fat, protein, and SNF). However, morning milking consistently produced higher levels of milk components (Table 3).

Table 3. Milk composition with and without sorghum silage supplementation

Feed type and milking time	Milk composition				
	Fat (%)	Protein (%)	SNF (%)	Density g/ml	Water added
Cows with silage supplementation					
Morning	4.44	4.08	10.01	36.53	0
Evening	3.96	3.41	8.12	28.8	9.4
Mean	4.20	3.75	9.07	32.67	4.7
Cows without silage supplementation					
Morning	3.37	4.11	10.05	36.89	0
Evening	3.07	3.36	8.04	28.67	5.2
Mean	3.22	3.74	9.05	32.78	2.63
	NS	NS	NS	NS	NS

SNF, solid not fat
NS, non-significant

Feed quality improvement resulted in increased morning milk yield. The improvement was more evident in the dry season, where feed availability both in quantity and quality is always under question under the semi arid condition of Shoa Robit. Milk yield obtained from morning was found to be significantly different with silage supplementations ($P < 0.05$), and no yield difference was obtained from evening milking (Table 2). In the study crude protein content of the silage fall below the suggested critical level of 7.0 (Table 1), this requires additional protein source to correct the deficiency. The low protein content of the dried sorghum stalk, may partly explain the low milk yield in the study. The sorghum stalk, with its low protein content (Table 1), and low dry matter intake cannot provide sufficient degradable protein for adequate microbial growth. A number of researchers found significant correlation between dry matter intake and milk production, in which high intake promotes greater supply of nutrients for milk production (Getu *et al*., (2013); Adebabay, *et al*., (2009). This technology has a role to play in the improvement of sorghum stalk where it is used as a dry season supplementary feed. Necessary inputs such as urea, molasses, plastic sheet, chopper, and knowledge are in short supply in the locality. Unavailability of these materials may slow the adoption rate, hence, strong research-extension linkage and high engagement of local administration and other concerned sectors is crucial at the initial stage to introduce the technology.

Farmers ’perception about supplementary feeding

Farmers are aware of the seasonal difference in milk productivity. Sorghum silage supplement boosted production and increased household income. Though frequency of milking across the dairy production system is twice per day, Chare farmers practiced milking once a day in order to cope up with the feed shortage in the dry season. They realized that sorghum silage feeding not only maintained productivity during the peak dry season but also increased lactation length as opposed to the un-supplemented cows, which ceased milk production earlier. Unless lactating cows are supplemented with additional feed in the dry season, milk production either declines or ceases regardless of the lactation stage.

Farmers showed interest and were encouraged by the additional income they obtained due to extra milking period during the long dry season. Farmers described body condition of un-supplemented cows as relatively poor compared to the supplemented group. Milk price at Shoa-Robit, the nearest town is very high during the dry season since milk production in the area is low due to inadequate feed supply. Any cost incurred with silage preparation and feeding could be compensated by the high price of milk during the dry season with additional household income.

Conclusion

The result of this experiment indicated that good quality silage can be prepared from sorghum stalks after grain harvest at household level. Under the semi-arid conditions of Chare village, provision of sorghum silage at a rate of 6.0 kg per cow per day for indigenous lactating cows is advisable. The benefit obtained from silage feeding is satisfactory according to Chare village farmers. The improvement in milk yield performance is related to better concentration of protein, though not optimum, and succulence of the silage. Additional protein source could further improve milk yield and strategic supplementation would be necessary as sole silage does not meet the requirement of the lactating cows. Therefore, further work is needed to device specific supplements and additional protein sources to complement silage supplementation for increased milk production. So far, assistance to dairy development is focused on highland areas close to urban areas. Based on the outcome of this study, it is suggested that emphasis should be given to pocket lowland areas where milk production could be cost effective.

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